ELECTROACTIVE POLYMER (EAP) ACTUATING A DUST WIPER AND MINIATURE ROBOTIC ARM

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For many years, electroactive polymers (EAP) received relatively little attention due to the small number of available materials and their limited actuation capability. The recent emergence of EAP materials with large displacement response changed the paradigm of these materials and their potential capability. Their main attractive characteristic is their operational similarity to biological muscles, particularly their resilience and ability to induce large actuation strains. Unique robotic components and miniature devices are being explored, where EAPs serve as actuators to enable new capabilities. In recognition of the need for international cooperation among the developers, users and potential sponsors, an SPIE Conference was organized for the first time on March 1-2, 1999, in Newport Beach, California - largest ever on EAP. The conference marked an important milestone turning the spotlight onto these emerging materials and their potential. Further, the WW-EAP newsletter (http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/WW-EAP-Newsletter.html) was initiated to bring the worldwide EAP community even closer.

A challenge was posed to the EAP science and engineering community to develop a robotic hand that is actuated by EAP that is able to win against a human in an arm wrestling match (Figure 1). Progress towards this goal will lead to great benefits, particularly in the development and design of effective prosthetics. Decades from now, EAP may be used to replace damaged human muscles, leading to a "bionic human" of the future. My hope is to someday see a handicapped person jogging to the grocery store using this technology.

Figure 1: Grand Challenge for the EAP Community

At JPL, the planetary applications of EAPs are being explored as we improve the understanding, practicality and robustness of these materials. This research and development effort is conducted under the LoMMAs NASA task by a team consisting of JPL, NASA-LaRC, VT, Rutgers University, and ESLI having cooperative efforts with Osaka National Research Institute, Japan, and, Kobe University, Japan. Using a bending EAP material, a dust-wiper is being produced for the NASA/NASDA MUSES-CN mission. The development of the wiper is in an advanced stage, and if flown it would be the first recorded practical application ever recorded for such large actuation displacement EAP materials. This dust-wiper is being developed for the infrared camera window of the mission's Nanorover (Figure 2). The MUSES-CN mission is a joint effort between NASA and the Japanese Space Agency, scheduled for launch in January 2002 from Kagoshima, Japan, to explore the surface of a small near-Earth asteroid. The team is testing the use of highly effective ion-exchange membrane metallic composites (IPMC) made of perfluorocarboxylate-gold composite with two types of cations, tetra-n-butylammonium and lithium. Under a potential difference of less than 3-V, these IPMC materials are capable of bending beyond a complete circle. A unique ~100-mg blade with fiberglass brush was developed by ESLI (San Diego, CA), using a high voltage to repel dust, augmenting the mechanical brushing mechanism provided by the blade.

The team is jointly addressing challenges associated with flight applications, which are generally the most demanding in terms of operating conditions, robustness and durability. Several issues that are critical to the operation of IPMC are examined, including its response in vacuums and low temperatures, as well as the effect of the material's electromechanical characteristics on its actuation capability. The use of highly effective IPMC materials, mechanical modeling, unique components and a protective coating increases the probability of success for the EAP actuated dust-wiper. Another application of EAP actuators is the development of a miniature robotic arm with closed-loop control (Figure 3). A longitudinal EAP, based on SRI international developed actuator, is used to lift and drop the arm, whereas a 4-finger gripper is used to grab rocks and other objects. The bending EAP material shown in this figure was provided by UNM under a prior phase of the NASA LoMMAs task.

The practical application of EAP materials is still a great challenge. No effective and robust EAP material is currently commercially available. Further, there is no established database that documents the properties of existing EAP materials.

FIGURE 2: Schematic view of the EAP dust-wiper on the MUSES-CN's Nanorover (right) and a photograph of a prototype EAP dust-wiper (left).

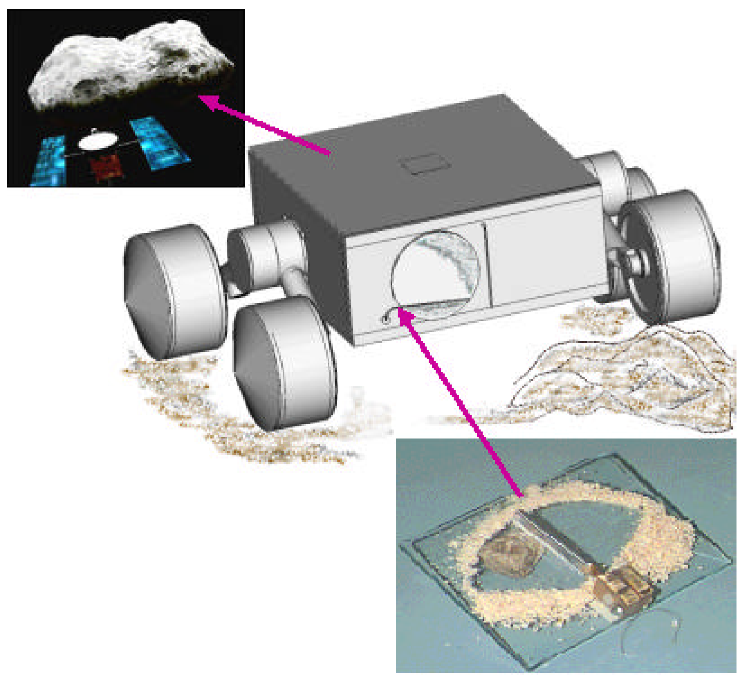

FIGURE 3: A miniature robotic arm using EAP actuators to provide the lifting/dropping of the arm and manipulate the gripper fingers.